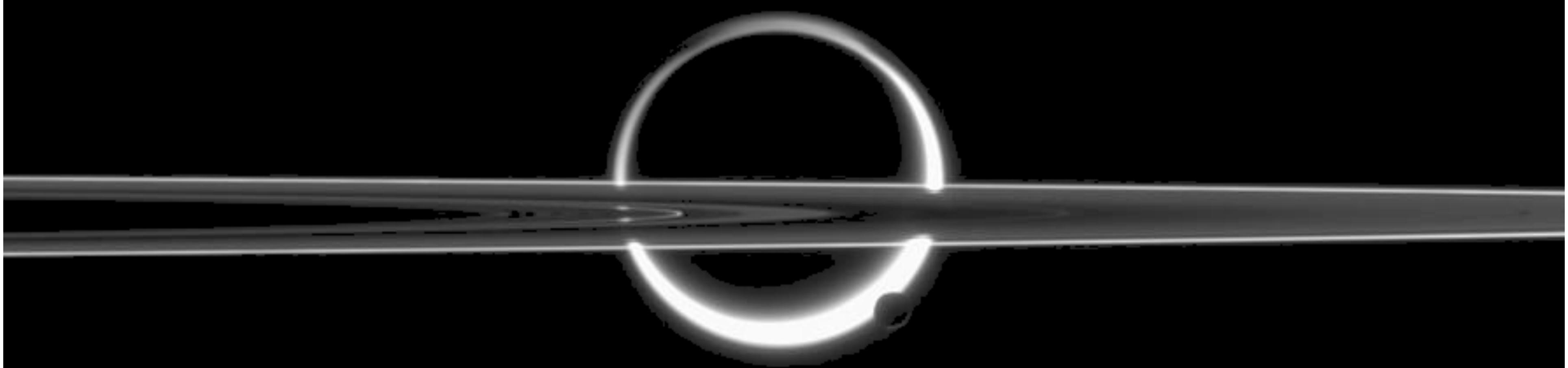
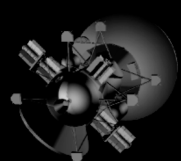
Titan Saturn System Mission
TSSM Orbiter Flight System





Presentation at OPFM Instrument Workshop

Presented by John Elliott

May 3, 2008

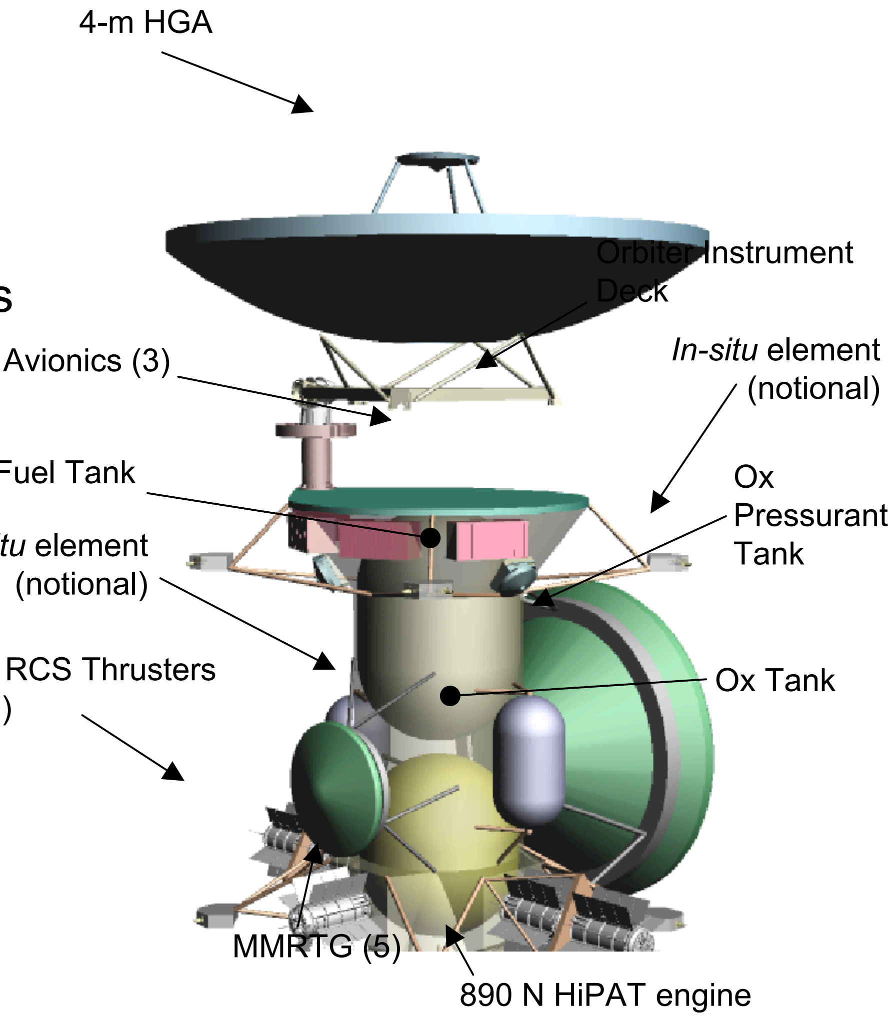
Jet Propulsion Laboratory, California Institute of Technology Pasadena CA

Key Study Requirements

- Propulsive (non Aerocapture)
  - Simpler packaging and thermal designs than Aerocapture design
  - Opportunity for Saturn science and Enceladus flybys (1-2 yr Saturn tour)
  - Much higher delta V than Aerocapture (+ ~3 km/s over 2007 study)
  - Longer flight time to Titan (+ ~12 months to get from SOI to Titan)
- $2.1 Billion FY07 cost cap
  - Strong budgetary preference for Atlas class LV
- Titan Orbit, Saturn System and Enceladus are Level 1 Science requirements
- MMRTG instead of ASRG
  - Higher mass, lower performance, higher degradation rate than ASRG
- Must accommodate In situ element
  - Added mass of in situ vehicle(s) leads to longer flight times for single launch
  - Physical interface for In situ vehicle
  - Shift in mass properties after in situ vehicle release
  - Communications interface with in situ vehicle(s)
- 2016-2017 Launch years

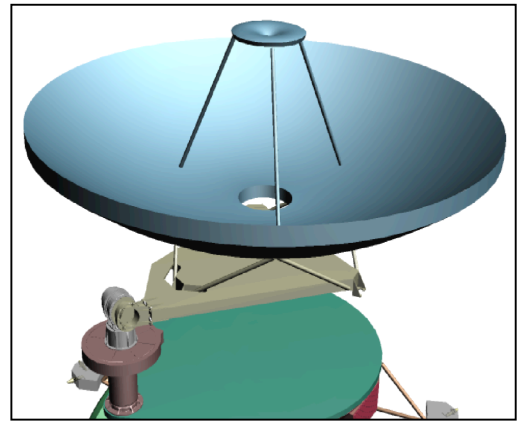
Spacecraft Configuration

- Configuration represents a balance of science, mass, cost & risk
- Spacecraft dry mass ~2200 kg including 33% margin
  - 150 kg allocated to orbiter instruments
    - 1-6 micron hi-res imager and spectrometer
    - Radar Sounder
    - Polymer mass spectrometer
    - Sub-Millimeter sounder
    - Mid-infrared radiometer and spectrometer
    - Magnetometer and plasma package
    - Radio science augmented by accelerometry
  - 400 kg for *in situ* elements
- Total Mission Dose estimated to be ~21 krad

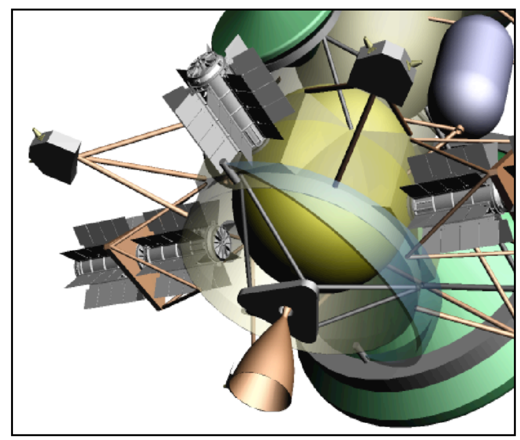


Configuration Features

- Telecom
  - MRO-like body mounted HGA
    - 4 m X/Ka dish with 35 W Ka TWTA
    - ~50 kbps from Titan at Ka to 34m DSN
    - Configuration chosen because:
      - Facilitates tighter pointing accuracy (req. 0.7mrad)
      - Allows larger dish in payload fairing (max. 4.5m)
      - Allows use of dish for Cassini-like ring crossing protection

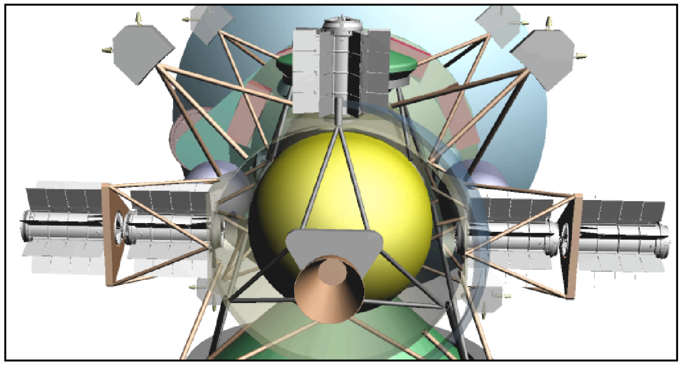


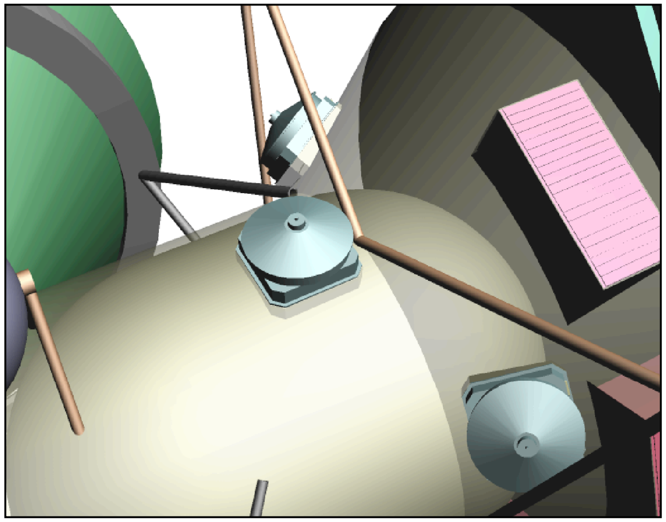
- Propulsion
  - Single gimbaled main engine (890 N)
    - Simplifies propulsion system, lower mass
    - Simplest accommodation of shifting CM resulting from probe release
    - Reduces RCS propellant requirements for TVC
    - during burns
  - 16 RCS thrusters (4.5 N) in 8 pods of two each
    - Retains redundant couples while minimizing number of thrusters



Configuration Features

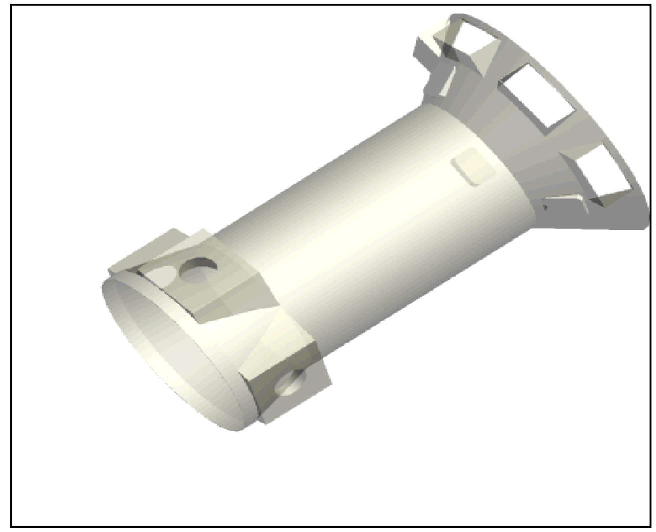
- Power
  - 5 MMRTGs provide primary power
    - ~475 W available at EOM
    - 25 Ahr batteries provide load leveling
- ACS
  - Three-axis stabilized S/C
    - RWAs, star trackers, IMU, OpNav Camera
  - Pointing control: 30 arcsec (3-sigma per-axis)
  - Pointing knowledge: 15 arcsec (3-sigma per-axis)
  - Pointing stability: 0.35 arcsec/sec (3-sigma per-axis)



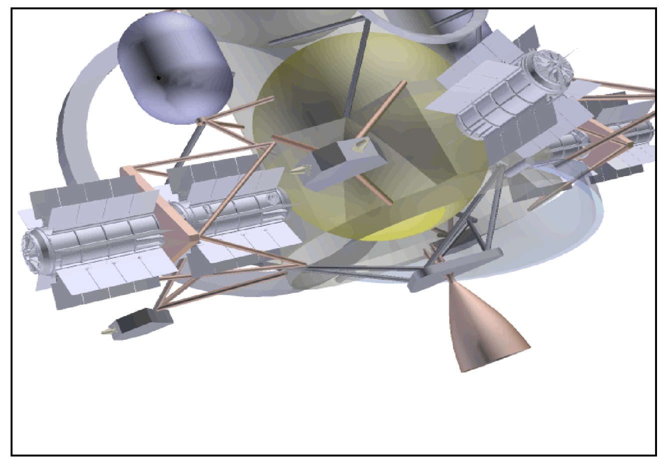


Configuration Features

- Structure
  - Combination of Composite and Aluminum primary structure
    - Minimizes mass with excellent rigidity

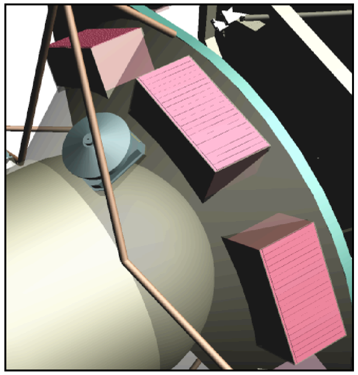


- Thermal Control
  - Electrical power requirements minimized through use of MMRTG waste heat and RHUs
    - MMRTG waste heat used to warm propulsion system
    - Thermal louvers, variable RHU's and thermostatically controlled electric heaters provide varying thermal energy as needed for different operational modes and solar distances



Configuration Features

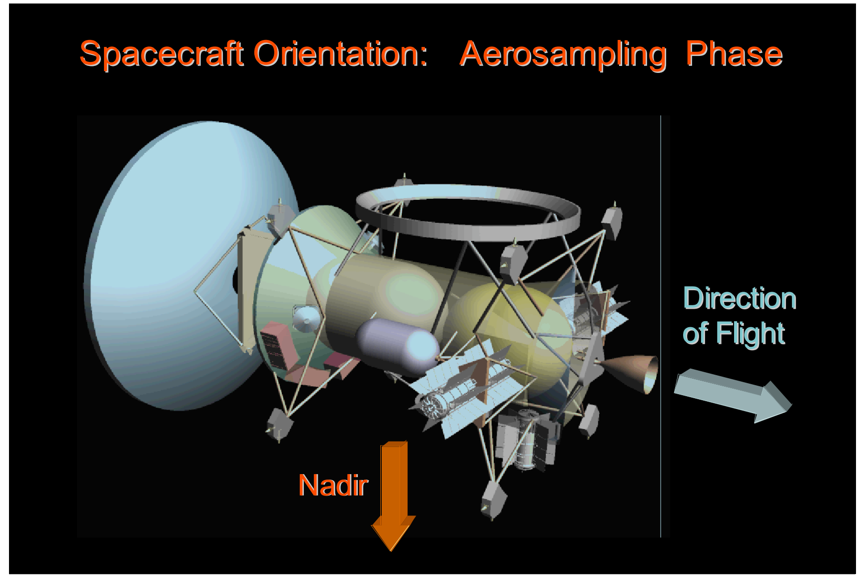
- C&DH
  - JPL MSAP based architecture
    - RAD 750 computer (132 MHz)
    - 32 Gb memory
    - Interfaces provided as listed

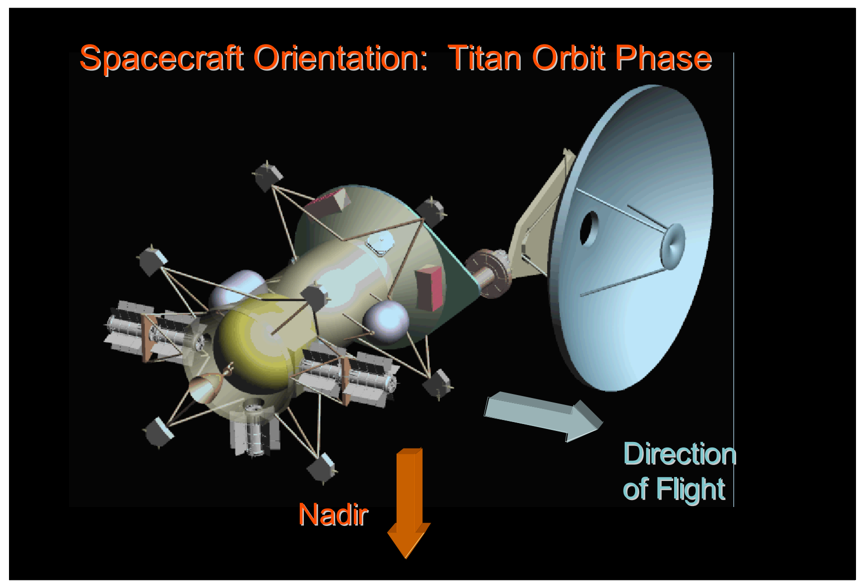


Interfaces					
	Number of Loads or Interfaces Supported	Number of Interfaces Currently Being Used	Number of Spares	Margin	Additional Constraints
1553	31	10	21	68%	Bus has 1 Mbps bandwith, don't exceed 600 kbps
RSB	31	8	23	74%	Bus has 1 Mbps bandwith, don't exceed 600 kbps
UART	2	0	2	100%	Supports up to 2 Mbps
ICC/ITC	4	4	0	0%	Supports up to 8 Mbps
Spacewire	4	0	4	100%	Supports up to 200 Mbps

Flight Orientation

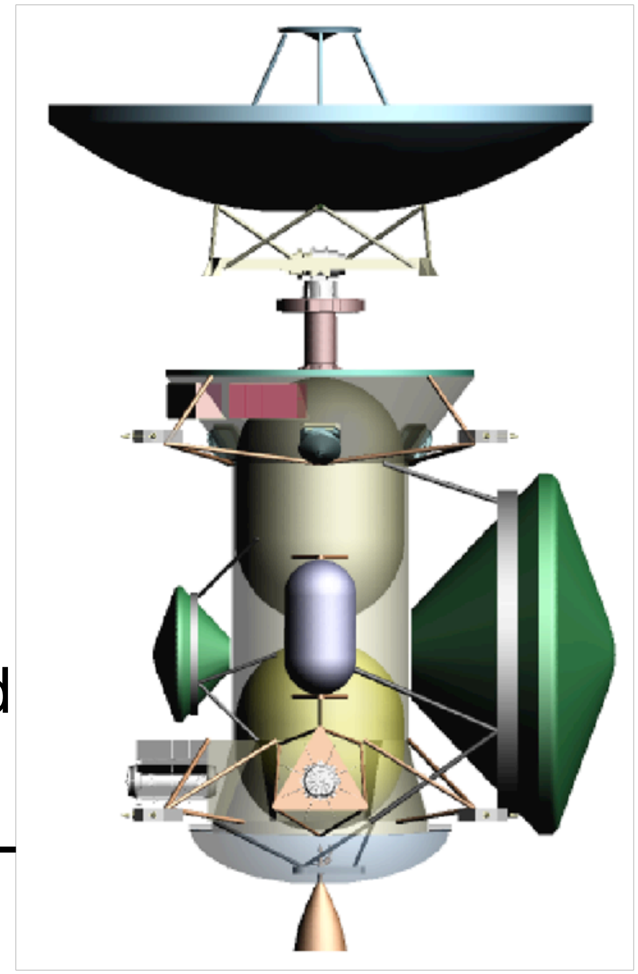
- Two flight system orientations are used in the mission
  - Aerosampling (during aerobraking) flies with engine in ram direction
    - Low Heating rates (<Mars)
    - Uses HGA for stability
  - Titan Orbit orientation perpendicular to that for Aerosampling
    - Change to accommodate HGA implementation
    - Nadir same direction





In-Situ Element Accommodation

- Current design provides accommodation for two in-situ elements
  - Planning target is one 2.6m aeroshell and one 1m aeroshell
    - Total target mass is 400 kg
  - Delivery would be pre-SOI
    - Mission of in-situ vehicles would be complete during Saturn Tour
  - Power and data interfaces provided pre-deployment
  - Orbiter provides telecom relay post-deployment using orbiter telecom system



Summary

- Spacecraft accommodates robust set of orbital instruments
- Orbital instrument environment relatively benign
- Gimbaled communications antenna decoupled from instrument platform
- Spacecraft accommodates ESA in situ payload
- Instruments responsible for radiators, but RHU's available for heating
- S/C Computer availability tbd.